Seafloor Sediment Permeability and Fabric Studies
In Support of the ONR-DRI Program
High Frequency Sound Interaction in Ocean Sediments

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LONG-TERM GOALS

The study and quantification of selected sediment properties important to the modeling of high frequency sound interaction in ocean sediments is the long-term project goal. Understanding of the coupling of sound into sediments, of propagation and attenuation within sediments, and of scattering from the sediment-water interface are the ONR program goals (Thorsos et al., 2001). The environmental measurements research thrust is two-fold. Part I is the *in situ* three-dimensional measurement and quantification of sandy sediment permeability. Part II is a quantitative study of the sediment microfabric, pore fluid pathways, porometry, and bio-organic components. A goal of the microfabric investigations is the development of microfabric models and related numerical analysis that describe important sediment properties such as fluid flow characteristics, tortuosity, isotropy and anisotropy, and stress-strain behavior.

OBJECTIVES

The objectives in FY-2002 were to provide a reliable statistical database of the fundamental *in situ* sediment permeabilities and to relate the microfabric and porometry characteristics to the hydraulic properties and related physical properties including tortuosity, isotropy and anisotropy (Bennett et al., 1996, 1989, 1990, 1999a and b). Following data analysis, additional tasks included completion of technical papers for the professional community with submission of a paper on the sediment *in situ* permeabilities to the special issue of the Journal of Oceanic Engineering.

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14. ABSTRACT
The study and quantification of selected sediment properties important to the modeling of high frequency sound interaction in ocean sediments is the long-term project goal. Understanding of the coupling of sound into sediments, of propagation and attenuation within sediments, and of scattering from the sediment-water interface are the ONR program goals (Thorsos et al., 2001). The environmental measurements research thrust is two-fold. Part I is the in situ three-dimensional measurement and quantification of sandy sediment permeability. Part II is a quantitative study of the sediment microfabric, pore fluid pathways, porometry, and bio-organic components. A goal of the microfabric investigations is the development of microfabric models and related numerical analysis that describe important sediment properties such as fluid flow characteristics, tortuosity, isotropy and anisotropy, and stress-strain behavior.

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APPROACH

The fabric studies incorporated refinements in, and extensions of, well-established techniques providing new capabilities that were originally used in the study of fine-grained sediments. The fabric analysis of sand included imaging of "undisturbed" samples that preserve the *in situ* structure and organic materials. As part of the study of these samples, we reconstructed the two- and three-dimensional fabric and pore fluid pathways, and determined the tortuosity of the sediments. The development of new methods, techniques, laboratory analyses, and digital image analyses was a major aspect of the research.

WORK COMPLETED

Permeability data were extensively analyzed with detailed error analysis performed to assess data quality and permeameter probe performance. *Quantitative fabric studies* (two-dimensional and three-dimensional) were conducted to analyze the porometry, pore fluid pathways, and related fabric and physical properties of the sandy sediment.

Our research team developed a high precision, novel, laboratory method for determining the sediment porosity of epoxy embedded sediment samples. A suite of sediment samples was analyzed to obtain a statistically representative characterization of the porosity and wet bulk density (calculated from the solid grain density, epoxy density, and volume measurements using embedded samples). A paper describing the technique with detailed statistics and error analysis is expected to be completed in FY-2003.

Accomplishments and work completed in FY-2002 by SEAPROBE and contributors are summarized as follows:

Papers in Press:

Bennett, R.H., M.H. Hulbert, C. Curry, H.P. Johnson, M. Hutnak and K. Curry, (In Press, 2002). In Situ Permeabilities of Selected Coastal Marine Sediments. In Press, IEEE.

Curry, K.J., M. Abril, J.B. Avant, C. Curry, R.H. Bennett and M.H. Hulbert, (In Press, 2002). A Technique for Processing Undisturbed Marine Sand Sediments and Reconstructing Fabric and Porometry. Journal of Sedimentary Research, Vol. 72, No. 6.

Hulbert, M.H., R.H. Bennett, R.J. Baerwald, R.L. Long, K.J. Curry, A.L. Curry and M.T. Abril, (In Press, 2002). Observations of the Sediment-Water Interface: Marine and Fresh Water Environments. Marine Georesources and Geotechnology, Vol. 20, No.4.

Poster Presentation:

Curry, K.J., C.W. Curry, M. Abril, A. Curry, R.H. Bennett and M.H. Hulbert, 2002. Porosity and Tortuosity of Sandy Marine Sediments: Fort Walton Beach, Florida. Abstract and Poster, Mississippi Academy of Sciences annual meeting.

Paper in Preparation:

Curry, C.W. et. al., (In Prep.). A Technique for Determining Porosity of Undisturbed Marine Sand: Comparison of Data from Laboratory and In Situ Electrical Conductivity Techniques.

IMPACT / APPLICATIONS

Acoustic behavior in sediment is complex. Reliable predictive capabilities (models, numerical formulations, and quantitative estimates) must consider the combined effects of the sediment properties at various scales depending upon the acoustic frequency of interest. Databases of *in situ* sediment properties are needed for the testing and evaluation of high frequency sound interaction models for shallow water coastal sediment types. These studies are providing important input parameters for modeling sediment behavior (acoustic and geotechnical) for coastal areas. The studies have direct impact on U.S. Naval activities including application to environmental management activities, mine burial problems, understanding of hydrology, processes, and engineering and acoustic problems involving objects placed on and in the sea floor.

TRANSITIONS

The project is providing necessary environmental data on the sediment physical properties and their variability including the fabric characteristics of sandy sedimentary deposits. These data are important to applied problems of interest to the Navy in areas of mine burial, buried mine performance, mine detection, pollutant migration in harbor sediments, and environmental impact assessment.

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Bennett, R.H., B. Ransom, M. Kastner, R.J. Baerwald, M.H. Hulbert, W.B. Sawyer, H. Olsen and M.W. Lambert, 1999a. Early Diagenesis: Impact of Organic Matter on Mass Physical Properties and Processes, California Continental Margin. Marine Geology, Vol. 159, p.1-34.

Bennett, R.H., H.W. Olsen, M.H. Hulbert, R.J. Baerwald, W.B. Sawyer and B. Ransom, 1999b. Organic Matter and Geotechnical Properties Interrelationships: Marine Sediments. In the Proceedings of the 13th ASCE Engineering Mechanics Division Specialty Conference, Johns Hopkins University, Baltimore, June 13-16, (CD-ROM).

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PATENTS

none